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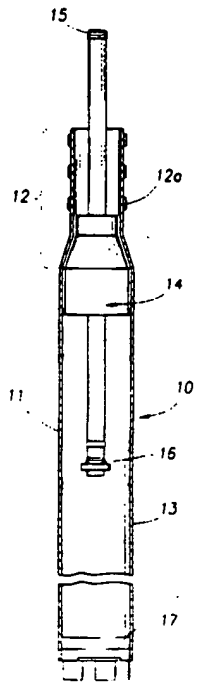
(54) Method and apparatus for cementing a well

(57) A method of cementing a well permitting a reduction in the degree of diameter reduction of casing or liners required, and not requiring excessively large initial conductor casing, is described. The method is characterized by provision of an enlarged wellbore and a novel liner structure which is adapted for expansion of a reduced diameter section thereof downhole, providing, before expansion of the section, unimpeded flow of fluid from the enlarged wellbore during cementing and close fit of the expanded section with the casing or preceding liner, after cementing is completed and expansion of the section. A novel well liner structure and novel well liner expansion means are disclosed.

FIG.2



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transmitting a fluid to the bore of the remainder segment of the second liner. to the end that a fluid under significant pressure may be applied to the bore of the remainder segment of the second liner. and further comprises means for connecting the die member to a drillstring.

According to the method of the invention. upon proper positioning of the liner-die assembly of the invention in the wellbore. cement slurry is then pumped down the drillstring through the casing or first liner and the second liner (via the means for transmitting a fluid) and into the enlarged wellbore annulus in an amount sufficient to cement the wellbore annulus. After the cement is in place. the bottom or bottom end of the second liner is sealed. by standard techniques known to those skilled in the art. to prevent egress of fluid from the liner. As utilized herein. reference to the "bottom" or "bottom end" of the liner is to be construed as referring to a site downhole on or in the liner rather than as a precise location of the liner body. The sealing of the bottom end of the liner. coupled with the seal provided by the fluid tight die member. provides or constitutes. assuming a location of the die member removed or distant from the bottom of the liner. and. with the exception of communication with the aforementioned means for transmitting a fluid. a sealed compartment or recess in the bore of the remainder segment of the second liner. Substantial fluid pressure is then applied to the interior of this sealed remainder segment recess by pumping a fluid. e.g.. a wellbore fluid such as a drilling fluid or a spacer fluid. through said means for transmitting a fluid which communicates with the compartment or recess. As fluid under pressure is introduced into the otherwise sealed recess. the increasing pressure therein tends to force the fluid tight die member up the second liner bore. According to the invention. as fluid pressure is increased in the sealed recess. the position of the die-expansion assembly. including the die member. is mechanically adjusted or allowed to adjust by translation upward in the liner (and the well-bore). The rate of upward adjustment or movement of the die-expansion assembly by upward movement of the running string and the application of pressure to the second liner bore recess are correlated so as to produce movement of the die member up through the section of reduced diameter with concurrent gradual deformation and expansion of the section of reduced diameter. providing an expanded section or segment having an external diameter equal to or approximating. preferably slightly greater or larger than that of the remainder segment of the second liner. as described more fully hereinafter. The expansion of the section provides an external diameter for the section which more closely approximates the internal diameter of the casing or first liner. while providing a larger flow passage internally for production fluids. Continued application of fluid pressure and correlated upward translation or adjustment of the position of the die-expansion assembly frees the die member from the second liner. the second liner then being positioned or allowed to remain with a substantial minor portion of the newly expanded segment in the casing or first liner. The cement slurry in the wellbore annulus is then allowed to set.

In yet further embodiments. the invention relates to a novel liner. which may additionally include expansion means therein. to an apparatus or tool for expansion of a liner having a reduced diameter section: and to a novel liner-die assembly or combination which is useful in cementing operations. More particularly. the liner of the invention comprises a wellbore liner having a minor section of reduced external and internal diameter composed of a deformable material and a larger remainder section of increased external and internal diameter The expansion device or apparatus of the invention comprises unique fluid tight die means adapted for expansion of a liner section of reduced internal and external diameter. and preferably comprises a means for transmitting a fluid. e.g.. a pipe: a die member adapted for expanding. at least substantially uniformly the bore of a liner. on the periphery of said pipe: and sealing means positioned on the periphery of the die member adapted to provide a fluid tight seal between the bore of a liner and said die member In the preferred arrangement the pipe is provided at one end thereof with means for connecting the pipe to. or for suspending the pipe from. a drillstring. and is further preferably provided at the opposite end thereof with means for suspending a tool. preferably components used in cementing operations. and. especially. in one aspect of the invention. means to assist in sealing the end of the liner distant from said opposite end of the pipe

The invention further relates to a novel liner-die assembly. In this aspect. the invention comprises the novel wellbore liner in which there is disposed the die-expansion assembly of the invention. as described. the assembly being disposed in said liner with the longitudinal axis of the means for transmitting fluid. or pipe. coincident with the axis of the liner and the fluid tight die member positioned in the remainder segment of the liner.

Brief Description of the Drawing

- Figure 1 illustrates schematically the prior art practice of telescoping liner sections.
- Figure 2 illustrates schematically a liner and liner assembly according to the invention.
- Figures 3 and 4 illustrate sectional views of liner expansion tools according to the invention.
- Figures 5 through 7 illustrate schematically the pipe expansion method or process of the invention.

For a fuller understanding of the invention. reference is made to the drawing. Accordingly, in Figure 1 there is shown a well string 1 extending to the earth surface 2 and to conductor pipe or casing 3. Conductor pipe 3 is positioned in the portion 4a of wellbore 4. while pipe 5 is in reduced diameter section 4b of the same wellbore The wellbore forms segmented annulus 6 with

construction. die member 28 may be mounted on pipe 25 by suitable mounting means (not shown). In a manner similar to the embodiment of Figure 3. the die member 28 comprises enlarged sections of variable diameter and is of generally frustoconical shape provided with suitable beveling in the segment of the die member where shaping of the liner section 12 will be initiated. although other deforming shapes of the die member may be provided. The die member 28 further comprises a fluid tight seal 29. as previously described.

The procedure of the invention and operation of the liner 10 assembly and die assembly 14 are understood more fully by reference to schematic Figures 5 through 7 Elements previously described with respect to Figures 1 through 4 are referred to by identical numbers. Accordingly. in Figure 5 the liner assembly is provided in a wellbore 30. such as an oil or gas well bore. and positioned in relation to cemented casing 31. as shown. Wellbore 30 has a diameter greater than the external diameter of casing 31. such wellbores being obtainable by use of a bi-center bit. under-reamer bit. or similar tool known to those skilled in the art. The external diameter of liner segment 13 is preferably slightly smaller than the internal diameter of casing 31. being just sufficiently smaller to allow lowering thereof through casing 31. The liner assembly is positioned in the enlarged wellbore. as shown. so that fluids. e.g.. drilling mud or cement slurry. may be passed down the string 1 and via the pipe or bore 25 into the liner segment 13 or suitable tools or structure therein. described more fully hereinafter. out of the liner segment 13. and into the wellbore annulus 32. and through the annulus segment 33. which is formed by the external wall of section 12 and the lower portion of casing 31. Liner section 12 is formed. as mentioned. of a deformable liner material. such as a metal. e.g.. steel or other alloy. which is suitable for liner duty. As used herein. the term "deformable" is understood in its common sense as indicating a capacity for shaping or expansion by suitable application of mechanical pressure. The fluid tight die assembly is positioned or disposed in the liner so that the longitudinal axes of the pipe and the liner are coincident. Pipe 25 may be of variable length and may or may not extend from liner 11. As will be evident to those skilled in the art. the invention is particularly adapted to use of liners of decreased wall thickness.

As previously mentioned. liner segment 13 is provided with suitable structure 17. at or near the end of the remainder segment of the liner. disposed from the die assembly. to allow ingress of fluid from the wellbore. such as a displacement fluid. during insertion of the liner. and sealing of the liner from ingress of cement slurry after cementing. In the usual case a differential fill-up collar will be employed at or near the bottom of the liner to prevent wellbore fluids from entering the liner. and any suitable such collar or similar device may be employed A variety of such devices are described in Well Cementing edited by E I Nelson. Schlumberger Educational Services (1990). and the selection of a particular device is well within the ambit of those skilled in the art. Additionally. in order to seal the bottom of the liner after the cement has been placed in the wellbore annulus. as more fully described hereinafter. suitable sealing means. known to those skilled in the art. may be provided to prevent egress of fluid from the liner. Preferably a wiper plug system is employed. to the effect that a fluid tight seal is formed at the end of the liner distant from the assembly. or the bottom of the liner.

In the position shown in Figure 5. the liner assembly is especially adapted to a cementing operation. and hanger elements are not required since the liner assembly may be supported by the string 1. More particularly following standard cementing procedures. cement slurry may be pumped downhole through the string 1 and through liner 11 via pipe 25 in the die assembly. through flow distributor 16. which may be that of the aforementioned wiper plug launching system. and out the bottom of the liner through open sealing means 17 The cement slurry displaces drilling fluid and/or a suitable spacer fluid between the cement slurry and the drilling fluid in the wellbore annulus. the drilling fluid and/or spacer fluid passing from annulus 32 into annulus 33 in casing 31 without substantial impediment. The advantage of the reduced cross section of segment 12 which permits flow of fluids out of the wellbore. is demonstrated at this juncture. Without such feature. the ultimate goal of a wider cross section for production fluids cannot be achieved because of the requirement for removal of fluids from the borehole annulus. Sufficient cement slurry is employed to fill the annulus 32. The invention now provides for expansion of section 12 to provide for a larger diameter cross section corresponding to that of section 13.

As shown in Figure 6. sealing means 17 (schematically shown) at the bottom of liner section 13 is sealed to the ingress and egress of fluid. In the normal case. a wiper plug. which is solid. is sent downhole. after sufficient cement slurry has been sent into annulus 32. to seal. with the differential fillup collar. the bottom of liner to egress of fluid. Fluid pressure is then applied to the bore of the liner segment 13 by pumping a fluid through the pipe 25 into the bore of liner 13. Any suitable wellbore fluid or liquid available may be used. e.g.. a displacement fluid. a completion fluid. water. or sea water. The fluid is pumped at sufficient pressure. e.g.. 3000 psi . through pipe 25 to provide upward movement of die member 28 if the member is freed for movement. To this end. the position of the die assembly (including die member 28) is adjusted or allowed to adjust upward by gradual upward movement of the running string 1. Adjustment of the drillstring length is made at a rate sufficient to move the die member upward or allow upward movement thereof. caused by the pressure on the die at a controlled rate in response to such continued sufficient application of fluid pressure the continued application of sufficient pressure being indicated by change

axis of the die assembly is disposed coincident with the axis of the liner

FIG.3

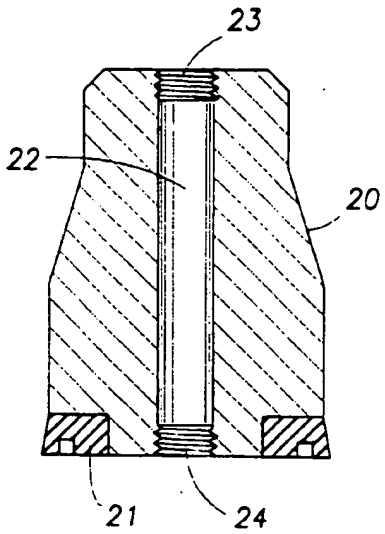
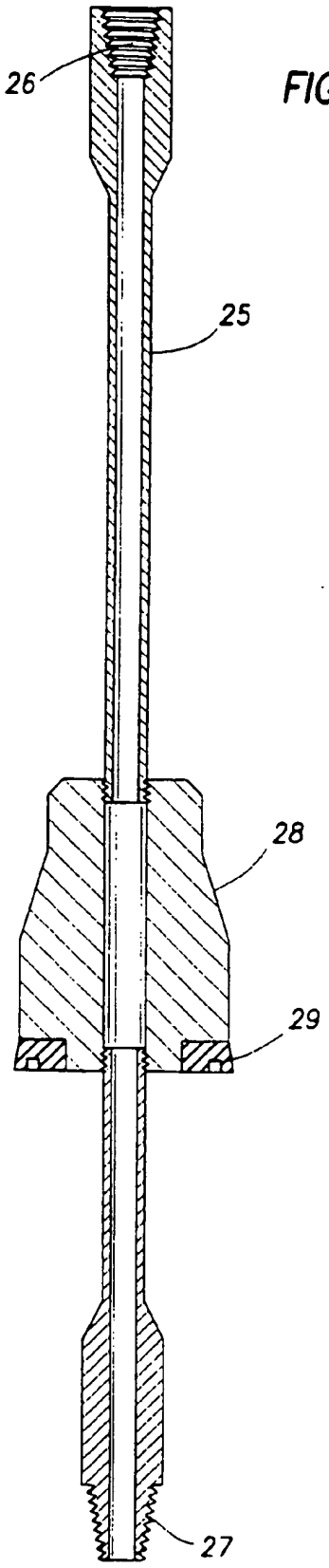


FIG.4



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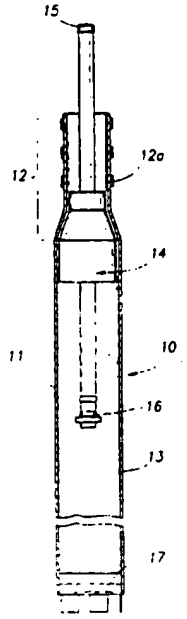

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